BMDE 610: Functional Neuroimaging Fusion

COURSE OUTLINE

Lectures Class time: Friday 8h30– 11h30
Class room: Duff 321

All course materials, slides will be posted online on Mycourses

Instructor Christophe Grova
Office: **Biomedical Engineering Department,**
E-mail: christophe.grova @mcgill.ca
christophe.grova@concordia.ca

Prerequisite: ECSE 305, MATH 223 or equivalent. The main requisites consist in being familiar with some notion of linear algebra (matrix multiplication, inversion) and statistics (Gaussian distribution, Bayes' rules)

Course description Multimodal data fusion of electrophysiology and functional neuroimaging data, including: detailed description of source localization methods for Electro- and Magneto-EncephaloGraphy data, analysis of brain hemodynamic activity through simultaneous recordings with electrophysiology, analysis and reconstruction of Near Infra-Red Spectroscopy data, modeling of the neurovascular coupling, validation methodology.

Learning Outcomes To gain sufficient knowledge regarding the complementaries and limitations of functional exploration techniques of brain activity: (i) electrophysiology: measuring neuronal bio-electrical activity with Electro- or Magneto-EncephaloGraphy (EEG vs MEG), (ii) hemodynamic processes: measuring indirectly the blood response to an activated brain region using functional Magnetic Resonance Imaging (fMRI) or Near Infra Red Spectroscopy (NIRS)

To understand the concepts of ill-posed inverse problem and multimodal fusion

To be able to critically assess most studies published in this field.

To be able to interprete EEG/MEG source localization results, fMRI results, NIRS results

To be able to chose a particular method/software when having to analyse such data

To be able to assess whether a new methodology was appropriately validated.

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Evaluation Procedure

(1) Mid-term exam: March 1st 2024 (Subject to change), 8h30:9h30 (**30%**)

- Understanding of important concepts
- Interpreting source localization results

(2) Assignment 1: March 22nd 2024 (15%):

- Implementing and testing source localization using Brainstorm software

(3) Participation (attendance): 5%

(4) Final Project: report (25%) oral presentation (25%):

- Detailed analysis of an article or a particular application of neuroimaging data fusion, with specific emphasis on validation methodology. The objective of the project is to present in details, the added value of using data fusion in a specific application context. *A clear and detailed understanding of the proposed methodology is expected*

  Oral presentation (25%): **April 12th 2024**

  Report (25%) – (8 pages, Times New Roman, 12pts): **April 19th 2024**

McGill policy statements

"McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures" (see www.mcgill.ca/students/srr/honest/ for more information). (approved by Senate on 29 January 2003)

"In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded." (approved by Senate on 21 January 2009 - see also the section in this document on Assignments and evaluation.)

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Proposed Outline (subject to small modifications to be updated on Mycourses)

Week	***Content***
Jan 5th	W1: 8h30-10h: Introduction W1: 10h-11h30: Basic principles in MEG/EEG, in fMRI/NIRS
Jan 12th	W2 : 8h30-9h30 : Important concepts: Multimodal fusion W2 : 9h30-10h30 : Important concepts: Validation Methodology W2: 10h30-11h30: Equivalent current dipoles
Jan 19th	W3: 8h30-11h30: Generative models (forward pb): EEG/MEG **(N. V Ellenrieder)**
Jan 26th	W4: 8h30-10h: Dipole scanning approaches (MUSIC, Beamformer) W4 : 10h-11h30: Distributed models 1: Min Norm, LORETA, L1
Feb 2nd	W5: 8h30-10h: Distributed models 2: anatomical MRI constraints W5: 10h-11h30: Distributed models 3: Hierarchical Bayesian Models
Feb 9th	W6: 8h30-10h00: Distributed models 4: MEM, Fusion EEG/MEG W6: 10h00-11h30: Brainstorm software training
Feb 16th	W7: 8h30-10h: Time-Frequency analysis of EEG/MEG (**J.M. Lina**) W7: 10h-11h30: Time-Frequency based source localization (**J.M.Lina**)
Feb 23rd	W8: 8h30-10h: fMRI analysis: Study design, GLM, Bayesian Models, W8: 10h-11h30: Simultaneous EEG/fMRI in epilepsy (**J. Gotman**)
March 1st	**W9: 8h30-9h30: Midterm exam** W9: 9h30-11h30: Atlas of intracranial EEG data **(B. Frauscher)**
March 8th	W10: No class, reading week
March 15th	W11: 8h30-10h: fMRI analysis: Multiple comparison W11: 10h-11h30: Exploring oscillatory brain networks with MEG and intracranial EEG (**K. Jerbi**)
March 22nd	W12: 8h30-10h: Computational modeling involving neuronal, hemodynamic and metabolic activity (**H. Benali**) W12: 10h-11h30: fMRI analysis: functional connectivity (**B. Bernhardt**)
March 29th	No class Easter Friday
April 5th	W13: 8h30-10h: NIRS analysis: GLM, deconvolution, inverse problem W13: 10h-11h30: Comparative / Constrained / Symmetrical Fusion
April 12th	**W14: 8h30-11h30: Final projects / Oral presentations**